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(54) **MULTIMEDIA FEATURE FOR DIAGNOSTIC INSTRUMENTATION**

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This patent is subject to a terminal disclaimer.

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(51) **Int. Cl.**[7] **A61B 5/00**

(52) **U.S. Cl.** **600/559**

(58) **Field of Search** 600/559

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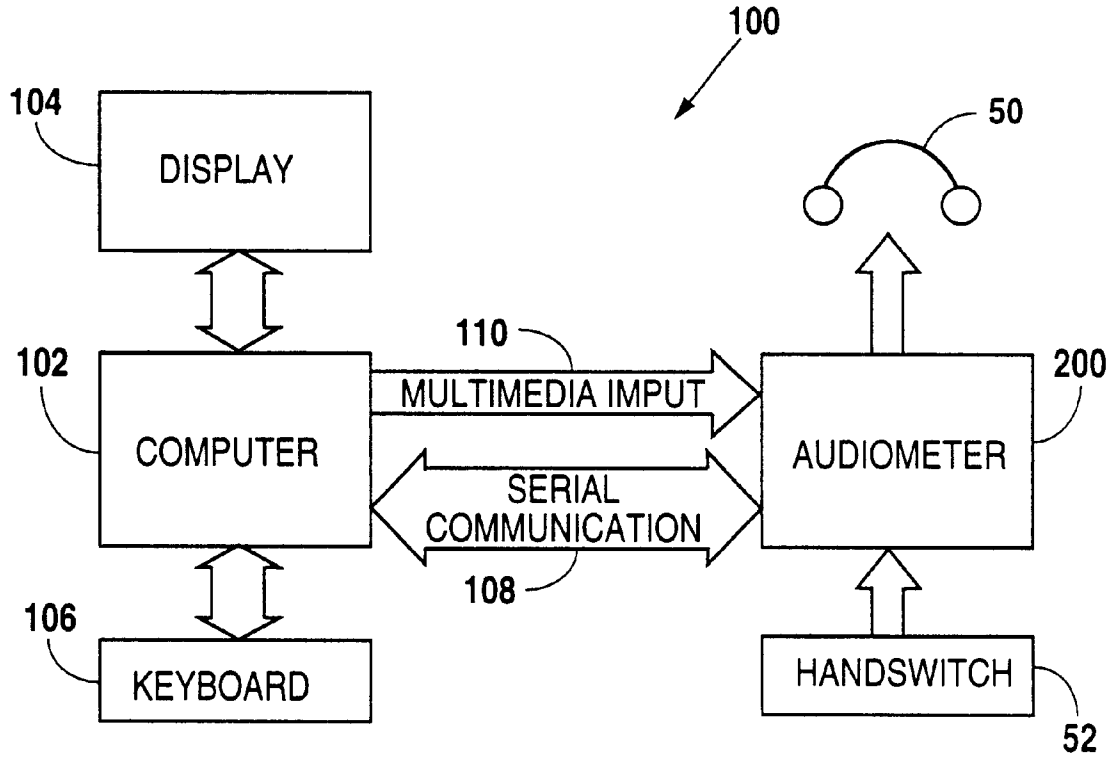
(57) **ABSTRACT**

A method for automatedly administering an audiometric test includes the steps of controlling an audiometer to selectively switch the audiometer output between test tones generated by the audiometer and sound signals generated from digital information; first switching the audiometer output to sound signals when the step of controlling indicates a beginning of a new test, a completion of a current test, or a test error; outputting sound representative of the sound signals after the step of first switching; second switching the audiometer output to test tones after the step of outputting; and outputting test tones until the next step of first switching.

14 Claims, 8 Drawing Sheets



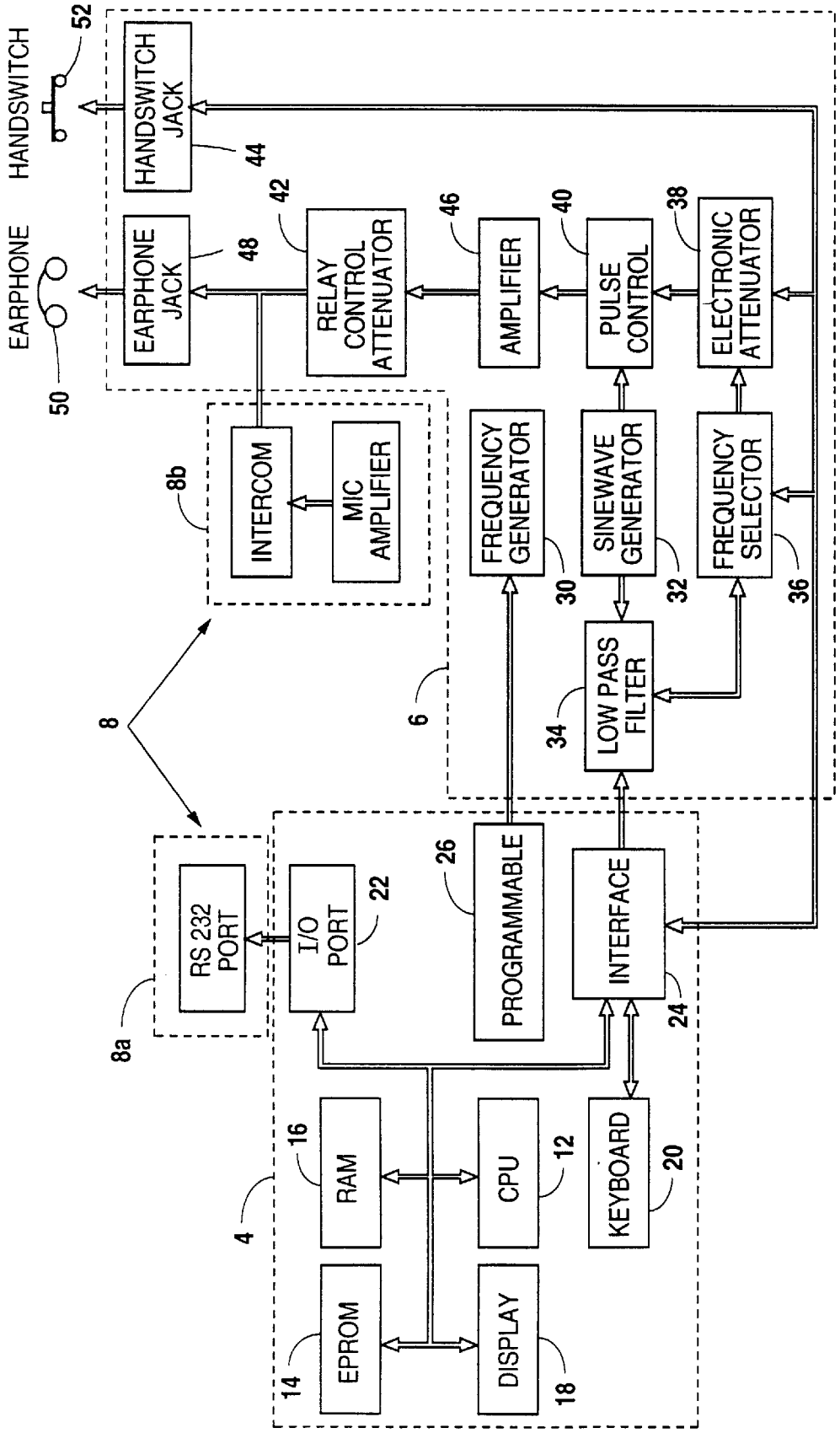


Fig. 1
(PRIOR ART)

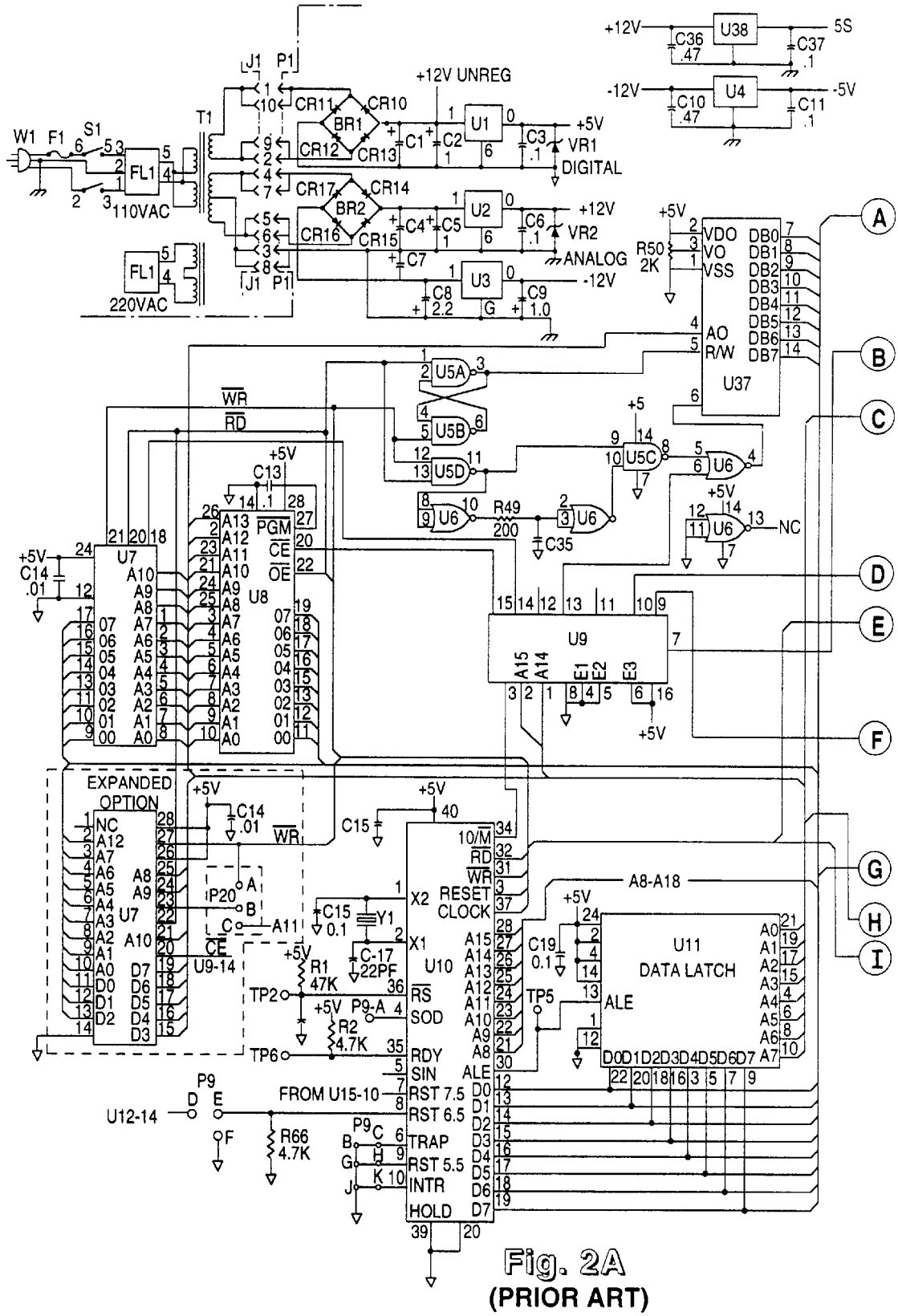


Fig. 2A
(PRIOR ART)

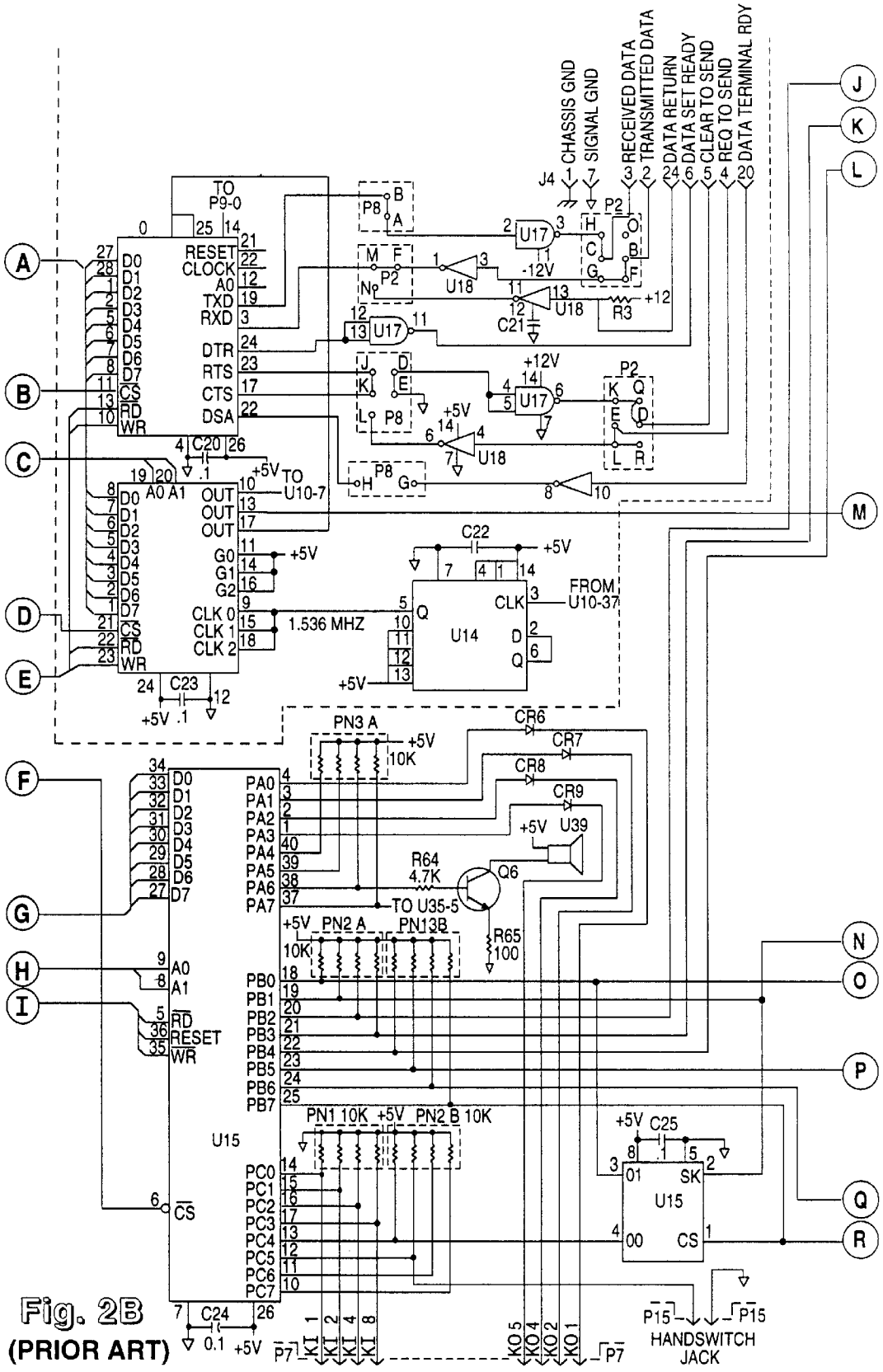


Fig. 2B
(PRIOR ART)

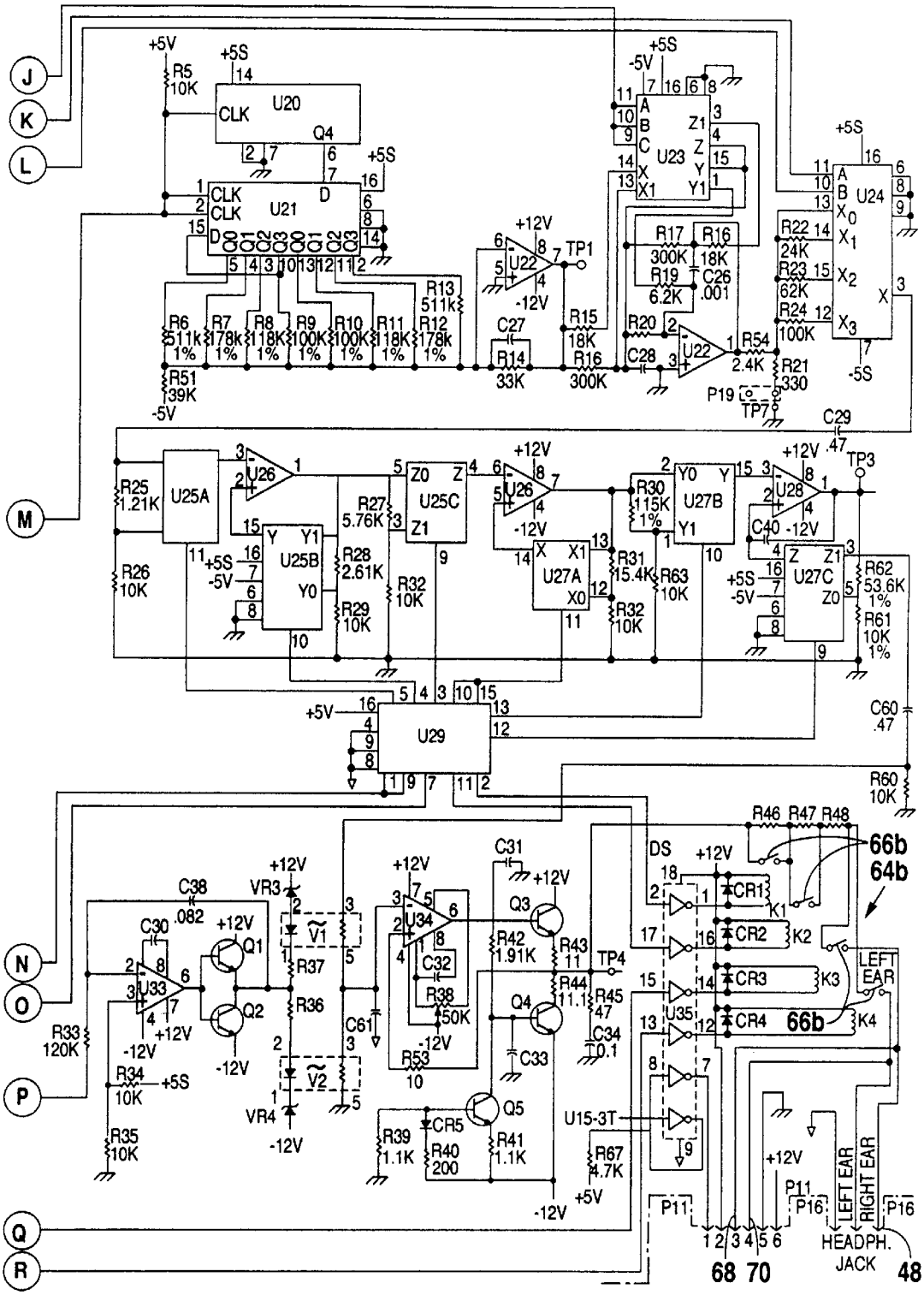


Fig. 2C
(PRIOR ART)

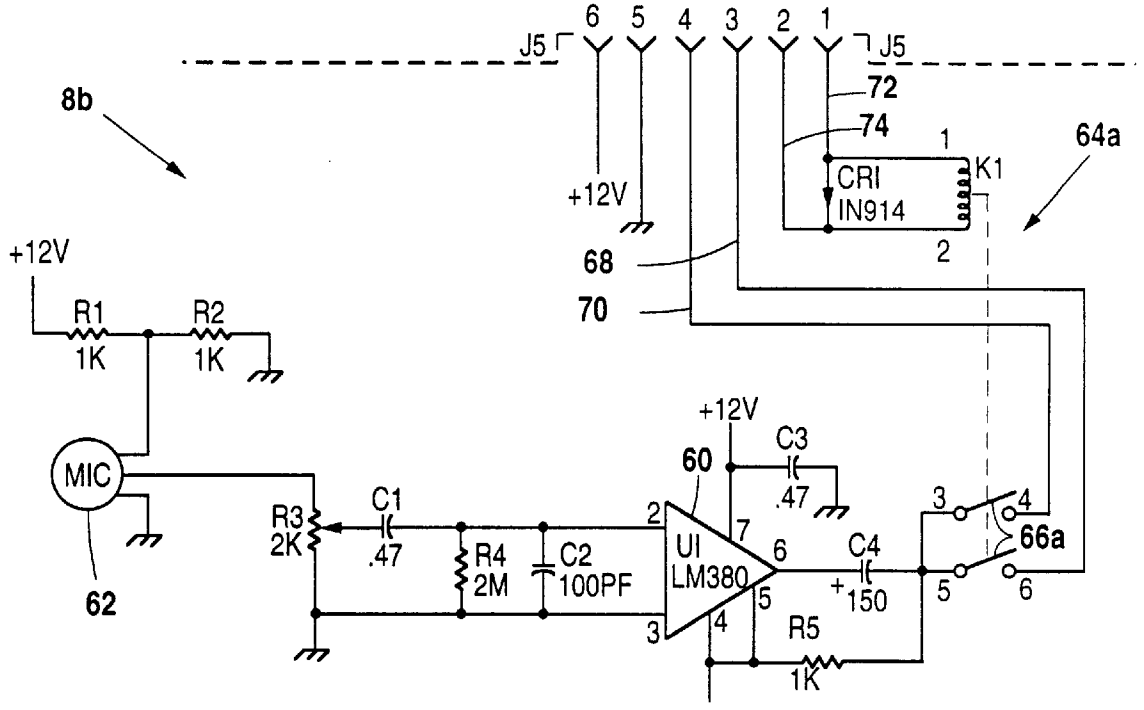

J5
6 5 4 3 2 1
J5
72
74
8b
64a
1
CRI
IN914
K1
2
+12V
+12V
68
70
R1
1K
R2
1K
+12V
C3
.47
60
MIC
R3
2K
C1
.47
R4
2M
C2
100PF
UI
LM380
C4
+150
66a
62
R5
1K

Fig. 3

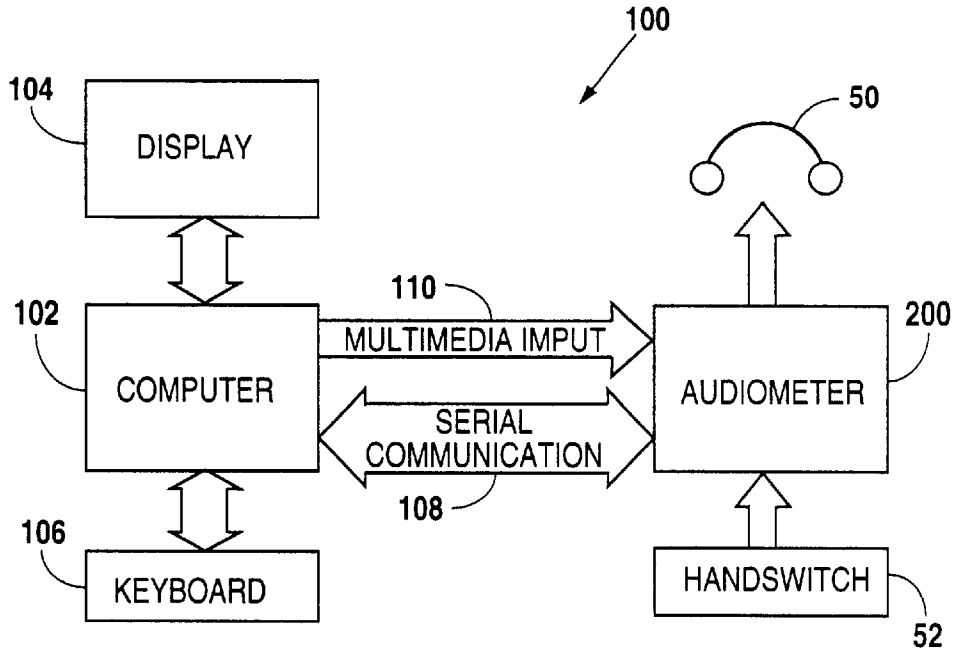

100
104
DISPLAY
50
110
102
MULTIMEDIA IMPUT
200
COMPUTER
AUDIOMETER
SERIAL
COMMUNICATION
108
106
KEYBOARD
HANDSWITCH
52

Fig. 4

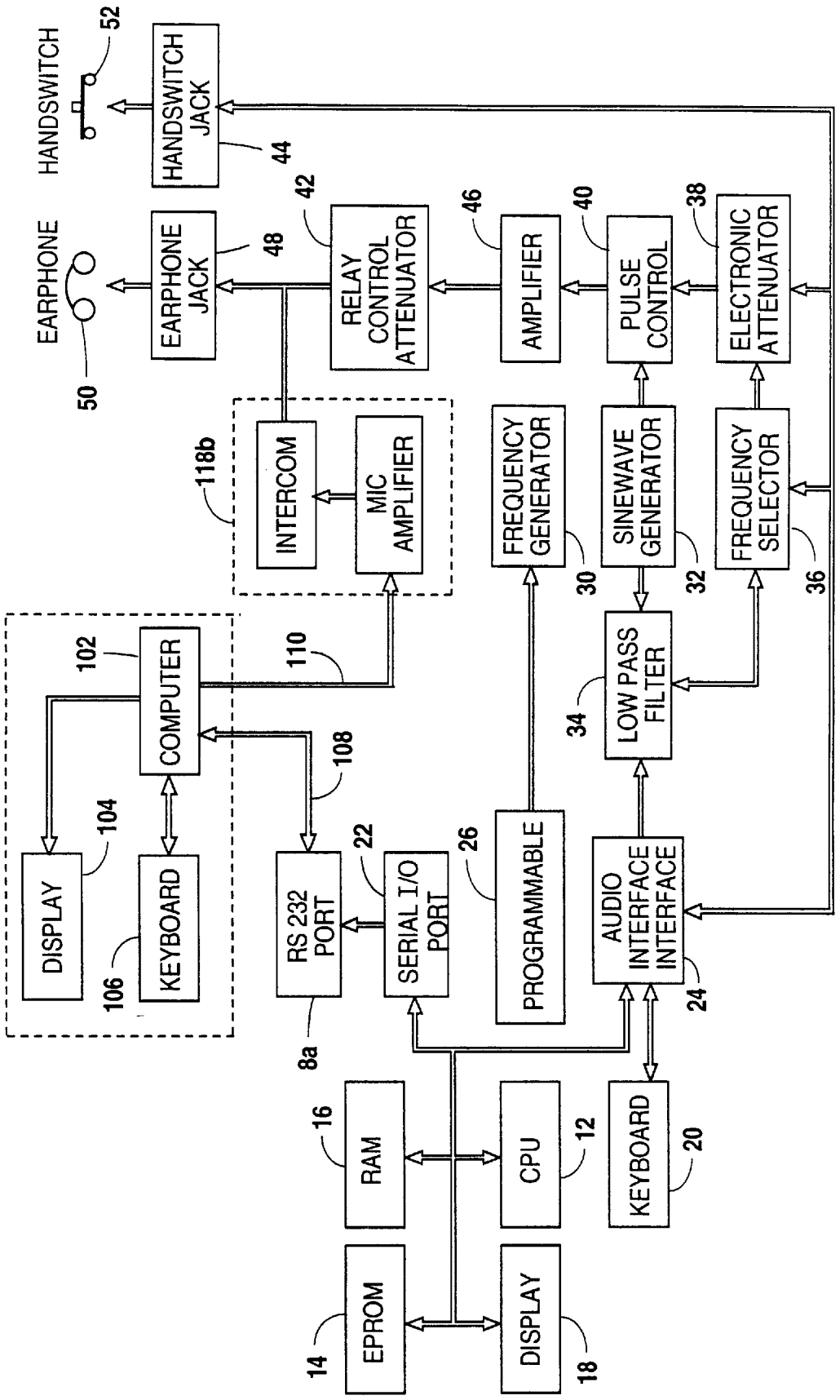
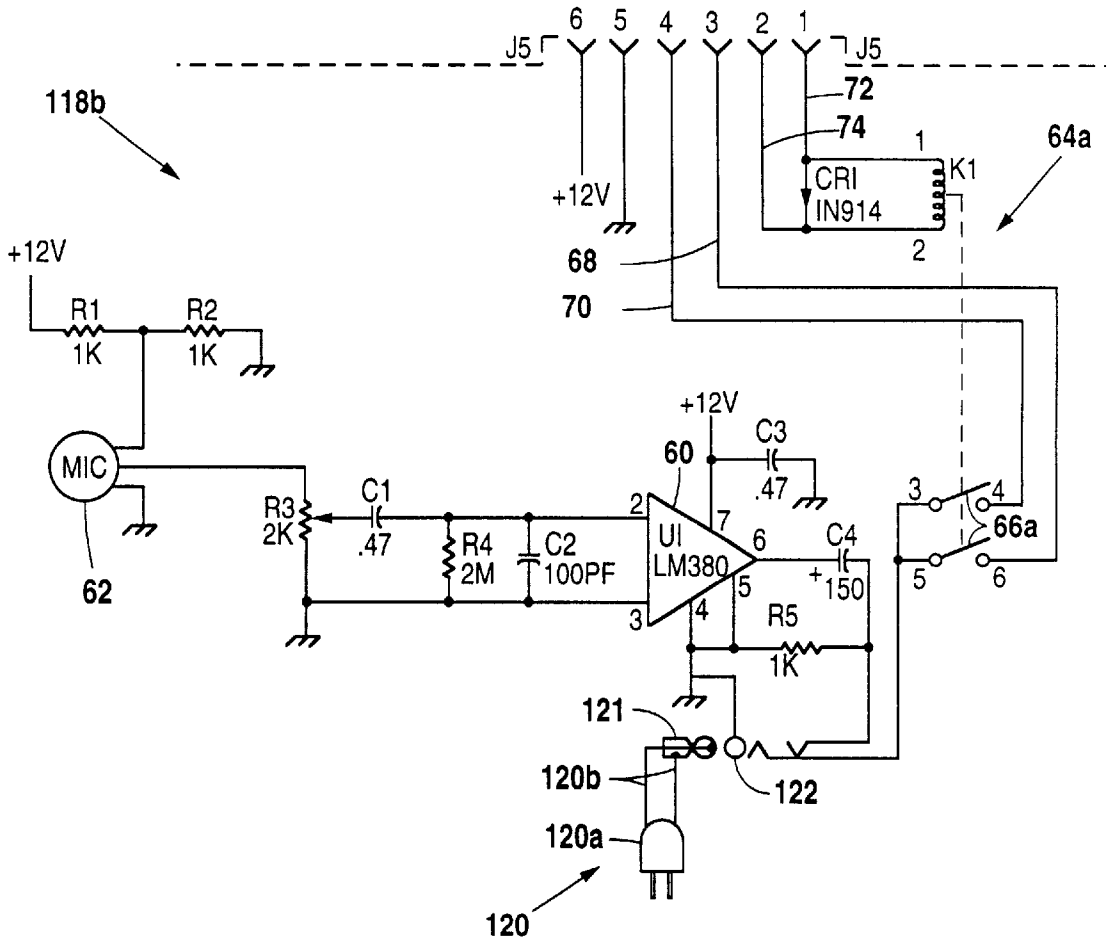

HANDSWITCH
52
HANDSWITCH JACK
44
EARPHONE
50
EARPHONE JACK
48
42
RELAY CONTROL ATTENUATOR
46
AMPLIFIER
40
PULSE CONTROL
38
ELECTRONIC ATTENUATOR
118b
INTERCOM
MIC AMPLIFIER
FREQUENCY GENERATOR
30
SINEWAVE GENERATOR
32
FREQUENCY SELECTOR
36
102
COMPUTER
110
LOW PASS FILTER
34
104
DISPLAY
106
KEYBOARD
108
RS 232 PORT
22
SERIAL I/O PORT
26
PROGRAMMABLE
AUDIO INTERFACE INTERFACE
24
8a
16
RAM
CPU
12
KEYBOARD
20
14
EPROM
DISPLAY
18

Fig. 5


6 5 4 3 2 1
J5
J5
72
74
118b
64a
1
K1
CRI
IN914
2
+12V
+12V
68
70
R1
1K
R2
1K
+12V
C3
.47
60
MIC
C1
.47
R3
2K
R4
2M
C2
100PF
UI
LM380
C4
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4
66a
5
6
62
R5
1K
121
120b
122
120a
120

Fig. 6

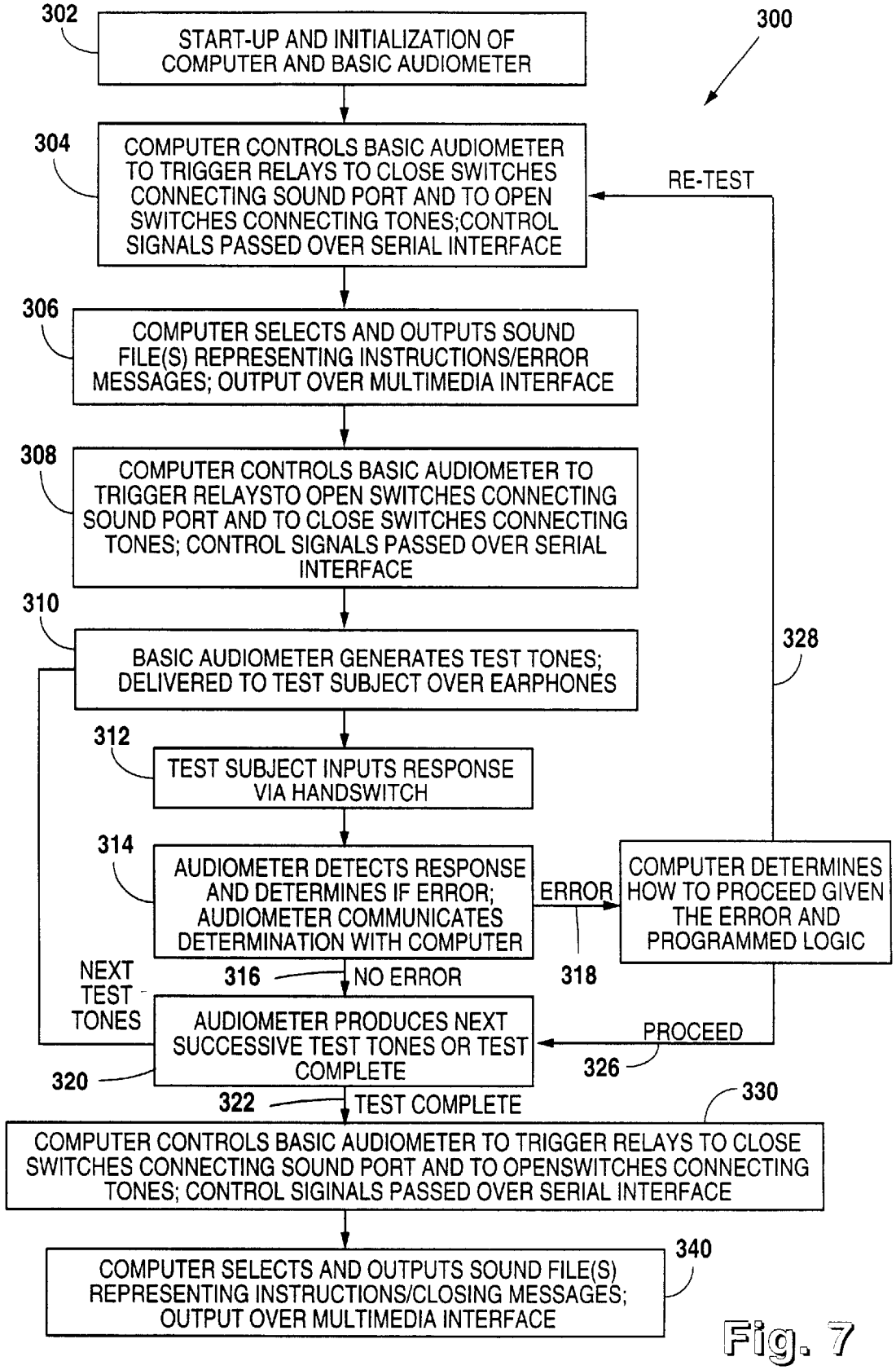
302
START-UP AND INITIALIZATION OF COMPUTER AND BASIC AUDIOMETER
300
304
COMPUTER CONTROLS BASIC AUDIOMETER TO TRIGGER RELAYS TO CLOSE SWITCHES CONNECTING SOUND PORT AND TO OPEN SWITCHES CONNECTING TONES;CONTROL SIGNALS PASSED OVER SERIAL INTERFACE
RE-TEST
306
COMPUTER SELECTS AND OUTPUTS SOUND FILE(S) REPRESENTING INSTRUCTIONS/ERROR MESSAGES; OUTPUT OVER MULTIMEDIA INTERFACE
308
COMPUTER CONTROLS BASIC AUDIOMETER TO TRIGGER RELAYSTO OPEN SWITCHES CONNECTING SOUND PORT AND TO CLOSE SWITCHES CONNECTING TONES; CONTROL SIGNALS PASSED OVER SERIAL INTERFACE
310
BASIC AUDIOMETER GENERATES TEST TONES; DELIVERED TO TEST SUBJECT OVER EARPHONES
328
312
TEST SUBJECT INPUTS RESPONSE VIA HANDSWITCH
314
AUDIOMETER DETECTS RESPONSE AND DETERMINES IF ERROR; AUDIOMETER COMMUNICATES DETERMINATION WITH COMPUTER
ERROR
COMPUTER DETERMINES HOW TO PROCEED GIVEN THE ERROR AND PROGRAMMED LOGIC
318
NEXT TEST TONES
316
NO ERROR
AUDIOMETER PRODUCES NEXT SUCCESSIVE TEST TONES OR TEST COMPLETE
PROCEED
326
320
322
TEST COMPLETE
330
COMPUTER CONTROLS BASIC AUDIOMETER TO TRIGGER RELAYS TO CLOSE SWITCHES CONNECTING SOUND PORT AND TO OPENSWITCHES CONNECTING TONES; CONTROL SIGINALS PASSED OVER SERIAL INTERFACE
340
COMPUTER SELECTS AND OUTPUTS SOUND FILE(S) REPRESENTING INSTRUCTIONS/CLOSING MESSAGES; OUTPUT OVER MULTIMEDIA INTERFACE

Fig. 7

MULTIMEDIA FEATURE FOR DIAGNOSTIC INSTRUMENTATION

This application is a continuation of application Ser. No. 08/639,694 filed on Apr. 29, 1996 and U.S. Pat. No. 5,811,681.

BACKGROUD OF THE INVENTION

The present invention relates to a multimedia interface of a diagnostic test instruction and, more particularly, to automated testing, including multimedia-derived instruction, test monitoring, and error response, by an audiometer or other medical or diagnostic test instrument.

A wide variety of medical and diagnostic test instrumentation is known. An example of such instrumentation is an audiometer. The audiometer is an electrically activated generator of test tones for evaluation of hearing. Other medical and diagnostic instrumentations include a spirometer for measuring lung capacity, vision testing equipment, blood alcohol testing equipment, and occupational health industry maintenance testing equipment, such as blood pressure, EKG, and other wellness testing equipment. Generally, these and other prior testing instrumentations require one or more individuals to administer the test by operating the equipment and giving instructions to the test subject.

The trend in testing, however, appears to be toward automation. Through automation, reduced numbers of test administrators may be required and increased accuracy of testing, with lack of deviation caused by human administrator error, may be possible. Although certain limited automation has previously been possible, that automation has been directed primarily to the automated compilation, organization, and reporting of data in desirable formats. Processing units, such as, for example, personal computers, have previously been employed to achieve the automation of the compilation, organization, and reporting functions. Little automation, if any, has previously been achieved, however, in connection with the actual administration of the test. Administration of such tests has typically been performed almost wholly by one or more human test administrators.

Hearing testing has for several decades been performed utilizing an instrument called an audiometer. Prior to the audiometer, tuning forks and other tone generating devices were employed. In the early testing, a test subject responded directly to a test administrator who recorded test results based on the administrator's subjective determinations. The advent of the audiometer, an electronic instrument that generates tones, provided a degree of standardization in hearing testing because uniform tones and proper calibrations are better achieved.

Even after the invention of the audiometer, however, hearing testing was far from standardized, as testing varied in both procedures and determinations. A standardized procedure, still followed today, was then developed for hearing testing. That procedure is referred to as the "Hughson-Westlake" procedure. Other procedures are followed in some instances, but the Hughson-Westlake procedure is probably the most common.

In the Hughson-Westlake procedure, tones at a level audible to the test subject, such as, for example, 30 dB, are first presented to the subject. The test subject responds that the tones are heard, and then the level of the tones are reduced by 10 dB. This is repeated with the test subject responding that the tones are heard followed by 10 dB reductions until the test subject's response (or lack of response) indicates that the tones are not heard. When the test subject so responds that the tones are not heard, the tone level is raised 5 dB. If the test subject does not then respond, the level is raised another 5 dB, and this is repeated until the subject signals that the tone is heard. This entire process is repeated until the test subject has three ascending positive responses at the same level. In order to make comparison of hearing quality over time, a first test is administered to establish a base line hearing level and later testing, undertaken at subsequent time intervals, provides results for comparison to base line. The comparison indicates any hearing loss or other changes over time.

As with diagnostic and industrial health testing instruments, generally, audiometers have progressed towards more automation. Also as with other instruments, however, automation of audiometers has typically focused on compilation, organization, and reporting of test results. The automation has not been directed to replacement of a human test administrator (or at least the traditional functions of such an administrator) by a machine automated process.

As previously mentioned, automation, particularly by a machine such as a computer, achieves certain advantages. In particular, the testing may be more uniform among subjects and test periods, whereas testing is subject to variation when a human test administrator administers and grades the test. Also, supplying human test administrators to conduct tests is rather costly. Reducing the required number of test administrators through further automation of testing procedures may reduce or eliminate those costs. Furthermore, test presentation and determined results may vary among human test administrators. More standardized and accurate testing may be possible if intervention of a human test administrator is reduced through further automation. In addition to those advantages, certain automation may provide added advantages, for example, multi-lingual test administration, multiple simultaneous different tests, multiple simultaneous test subjects, visual features, and other possibilities.

Embodiments of the present invention provide advantages of multimedia automation in diagnostic testing employing electronic or other instrumentation. The embodiments are particularly suited in the case of an audiometer, however, numerous other applications of the embodiments are possible. The above-described advantages, as well as other advantages, are achieved through the embodiments. The present invention is, thus, a significant improvement in the art and technology.

SUMMARY OF THE INVENTION

An embodiment of the invention is a method for automatedly administering an audiometric test. The method comprises the steps of controlling an audiometer to selectively switch the audiometer output between test tones generated by the audiometer and sound signals generated from digital information, first switching the audiometer output to sound signals when the step of controlling indicates a beginning of a new test, a completion of a current test, or a test error, outputting sound representative of the sound signals after the step of first switching, second switching the audiometer output to test tones after the step of outputting, and outputting test tones until the next step of first switching.

Another embodiment of the invention is a multimedia audiometer. The multimedia audiometer comprises means for outputting sound signals generated from digital information, means for outputting test tones, means for switching between the means for outputting sound signals and the means for outputting test tones, and means for

controlling the means for switching, the means for controlling being communicatingly connected with the means for switching. The means for switching is communicatingly connected with the means for outputting sound signals and the means for outputting test tones.

Yet another embodiment of the invention is a multimedia audiometer. The multimedia audiometer comprises a computer, a tone generator, and a switch connected with the computer and the tone generator. The switch selectively causes either the tone generator or the computer to output sound waves, and the computer controls the switch.

Another embodiment of the invention is an audiometer. The audiometer comprises a processor, a memory, communicatingly connected with the processor, for storing digital data, a sound wave generator, for generating analog sound signals in respect of digital data, electrically connected with the processor, a test tone generator electrically connected with the processor, and a switch connected with the sound wave generator, the test tone generator, and the processor. The switch is controlled by the processor to selectively cause either the sound wave generator or the test tone generator to output sound waves.

A further embodiment of the invention is an instrument that conducts a test protocol on a test subject. The test protocol comprises an output by the instrument followed by an input to the instrument. The test subject determines the input, which input may be positive, negative, or null. The instrument comprises an output generator, an input detector for detecting the input, a digital data storage for storing a digital data, a multimedia converter, the multimedia converter converts the digital data to an analog signal, and logic circuitry connected to the input detector, the digital data storage, the multimedia converter, and the output generator, for logically operating on the input, reading the digital data, delivering the digital data to the multimedia converter, and controlling the output generator.

Yet another embodiment of the invention is a multimedia audiometer. The multimedia audiometer comprises a basic audiometer, a computer, a multimedia input interface communicatingly connecting the computer and the basic audiometer, and a communications interface communicatingly connecting the computer and the basic audiometer.

Another embodiment of the invention is a diagnostic instrument. The diagnostic instrument comprises means for outputting an audible sound, means for generating a test tone, means for storing a digital data, means for generating an analog signal derived from the digital data, means for switching an output of the means for outputting between the test tone and the analog signal, the means for switching being electrically connected to the means for generating a test tone and the means for generating an analog signal, means for processing, means for inputting, the means for inputting connects the means for processing to the means for outputting, and means for communicating, the means for communicating connects the means for processing to the means for outputting, the means for generating the test tone, the means for storing the digital data, the means for generating the analog signal, the means for switching, and the means for inputting.

Yet another embodiment of the invention is a method of performing a diagnostic test protocol. The method comprises the steps of outputting an audible sound, generating a test tone, storing a digital data, generating an analog sound derived from the digital data, switching the audible sound from the step of outputting between the test tone and the analog signal, processing the digital data, and controlling the steps of outputting, generating the test tone, storing, generating the analog sound, and switching.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a functional block diagram of a conventional audiometer;

FIG. **2** is a detailed schematic of a typical audiometer, corresponding to the functional block diagram of FIG. **1**;

FIG. **3** is a schematic of a talkover card for use with the audiometer of FIG. **2**;

FIG. **4** is a block diagram of an audiometer interfaced with a personal computer for multimedia automation of audiometer testing;

FIG. **5** is a functional block diagram of an audiometer interfaced with a multimedia personal computer;

FIG. **6** is a schematic of the personal computer connection with the talkover card of FIG. **3**, to provide multimedia automation of audiometer testing; and

FIG. **7** is a flow diagram of a protocol for audiometric testing utilizing the multimedia features of the embodiments of the present invention to automate the test process.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1**, a functional block diagram of a conventional audiometer **2** may be described. Although the following discussion primarily addresses embodiments of the present invention employed for an audiometer, the embodiments have varied application in a wide variety of medical and diagnostic instrumentation. All those applications are intended as included within the scope of the invention. Also, the following describes various embodiments of the present invention as particularly employed with the conventional audiometer **2**. It is to be understood that the conventional audiometer **2** is detailed only for example purposes, and all other alternative audiometer configurations, as well as other instrumentation and configurations thereof, are also applications for the invention in accordance with the principles herein.

Conventional Audiometer

The conventional audiometer **2** is generally comprised of three parts: microprocessor circuitry **4**, audio circuitry **6**, and certain optional elements **8**. In addition to those three parts, the conventional audiometer **2** includes a power supply and related elements not shown in the functional block diagram. One example of the conventional audiometer **2** is the RA250 Microprocessor Audiometer available from TREMETRICS, Inc., Austin, Tex. Of course, as previously mentioned, the conventional audiometer **2** illustrated is shown only for purposes of illustration and example. Other audiometers and other types of medical and diagnostic instrumentation are also within the scope of the invention.

Microprocessor Circuitry

The microprocessor circuitry **4** of the conventional audiometer **2** may include a processing unit (CPU) **12**, such as, for example, an Intel™ 8085 microprocessor or another microprocessor. The CPU **12** serves to coordinate and control operations and functions of the conventional audiometer **2**. The CPU **12** conductively connects with various memory, such as, for example, erasable programmable read only memory (EPROM) **14** and random access memory (RAM) **16**. The memory **14**, **16** may serve to store a software protocol which controls the CPU **12** to cause the conventional audiometer **2** to provide audiometric functions. The memory **14**, **16** may also serve to maintain certain variables

to achieve desired operations and calibration of the conventional audiometer **2**, or simply to provide storage for values made available to and from the CPU **12**.

In addition to the memory **14**, **16**, the CPU **12** conductively connects with various input and output ports and peripherals. Input and output ports may include a serial I/O port **22** and a parallel interface **24**. The serial I/O port **22** may provide connections for certain optional elements **8**, as hereinafter discussed. The parallel interface **24** may connect with an input device, for example, a keyboard **20**. The parallel interface **24** may also connect with the audio circuitry **6**, as later explained. Another input device, such as a display **18**, for example, may connect with the memory **14**, **16**, CPU **12**, and other features of the microprocessor circuitry **4**. Such other features of the microprocessor circuitry **4** may include, for example, certain programmable registers **26** and other elements.

Audio Circuitry

Now discussing the audio circuitry **6** of the conventional audiometer **2**, the audio circuitry **6** interfaces with the microprocessor circuitry **4** in several ways. The programmable registers **26** may serve as ports that connect with an oscillator (also "frequency generator") **30**. The oscillator **30** may provide timing for a sine wave generator **32** that produces a digitally synthesized sine wave from which audible test tones are derived. Because the sine wave generator **32** produces a digitally synthesized wave, the wave may be smoothed by a low pass filter **34**.

The low pass filter **34** may connectively interface with the parallel interface **24** of the microprocessor circuitry **4**. Other elements of the audio circuitry **6**, such as a frequency selector **36**, an electronic attenuator **38**, a pulse control **40**, a relay control attenuator **42**, and a handswitch jack **44**, may conductively connect with the parallel interface **24** to complete the interface of the audio circuitry **6** with the microprocessor circuitry **4** of the conventional audiometer. Pursuant to this interface arrangement, the audio circuitry **6** and the microprocessor circuitry **4** may communicate signals for control and other purposes.

In addition to the connection of the low pass filter **34** with the parallel interface **24**, the low pass filter **34** may conductively connect with frequency compensation circuitry, such as, for example, a frequency selector **36** that, together with the control provided through the parallel interface **24**, helps compensate for attenuation. Other elements, such as the electronic attenuator **38** which connects with the frequency selector **36**, also provide compensation for attenuation. The sine wave generator **32** feeds the pulse control **40** which, together with input to the pulse control **40** from the electronic attenuator **38**, delivers signals representative of desired test tones to a power amplifier **46**. The power amplifier **46** feeds the relay control attenuator **42** for left and right earphone signals. The relay control attenuator **42** is conductively connected with an earphone jack **48**.

In order to allow a test subject to interface with the audio circuitry **6**, earphone speakers **50** and a handswitch **52** may be provided. The earphone speakers **50** may plug into the earphone jack **48**. The test subject wearing the earphone speakers **50** will then receive test tones generated by the conventional audiometer **2**. The handswitch **52** may plug into the handswitch jack **44**. The handswitch **52** provides means for the test subject to interface with the conventional audiometer **2** in order to signal to the conventional audiometer **2** that the test subject either does or does not correctly receive test tones through the earphone speakers **50**.

Options

In addition to the basic elements just described, the conventional audiometer **2** may include certain optional elements **8**. Various optional elements **8** are possible, depending upon desired operations and functions. Two common optional elements **8** of the conventional audiometer **2** have been an RS232 port **8***a* and a talkover card **8***b*. The RS232 port **8***a* may conductively connect to the serial I/O port **22** to allow communications of the microprocessor circuitry **4** with external peripherals (not shown) connected with the RS232 port **8***a*. Examples of external peripherals which may connect to the RS232 port **8***a* may include printers, terminals, and modems. The RS232 standard and suitable connections to ports conforming thereto are generally known.

The other of the common optional elements **8**, the talkover card **8***b*, is of particular significance in embodiments of the present invention. The talkover card **8***b* is conductively connected with the audio circuitry **6** of the conventional audiometer **2** between the relay control attenuator **42** and the earphone jack **48**. In effect, the talkover card **8***b* serves as a switch to divert input to the earphone jack **48** when desired by a human test administrator (not shown). The human test administrator may selectively "throw" the switch and cause the input to the earphone jack **48** to switch from signals from the relay control attenuator **42** representative of test tones to signals representative of the human test administrator's instructions then being voiced. Details of the talkover card **8***b* are hereinafter more fully discussed with respect to FIG. **3**.

Referring now to FIG. **2**, a detailed schematic of the conventional audiometer **2** of FIG. **1** is shown. Those skilled in the art will understand and appreciate the electrical elements and connectivities of the detailed schematic.

Referring now to FIG. **3**, a detailed schematic is provided of the talkover card **8***b* of the conventional audiometer **2**. The talkover card **8***b* comprises a fixed gain operational amplifier **60**. A voice microphone **62** is an input to the amplifier **60**. Other common electronic elements, such as, for example, resistors, capacitors, and others, may be included in the circuitry of the talkover card **8***b*. The amplifier **60** is connected to the input to the earphone jack **48** of the audio circuitry **6** of the conventional audiometer **2** (shown in FIG. **1**) by a relay **64***a*. When a human test administrator wishes to deliver voice sounds, rather than test tones, to a test subject wearing the earphone speakers **50** plugged into the earphone jack **48** (shown in FIG. **1**), the test administrator causes the relay **64***a* to be thrown. The test administrator, by such action, simultaneously causes the conventional audiometer **2** to interrupt the test then in progress, discontinuing test tone generation.

Referring to FIGS. **1–3**, in conjunction, the relay **64***a* when so thrown connects the amplifier **60**, across switches **66***a*, to the input to the earphone jack **48**. In particular, electrical connector **68** passes the voice signals from the amplifier **60** to the earphone jack **48** for delivery through the right ear speaker of the earphone speakers **50** and electrical connector **70** similarly passes the voice signals to the left ear speaker. When relay **64***a* results in closure of its switches **66***a*, relay **64***b* results in opening of its switches **66***b*, and vice versa. In this manner, either voice signals through the talkover card **8***b* or test tone signals through the audio circuitry **6** at any instant, but not both simultaneously, is delivered through the earphone speakers **50**. As those skilled in the art will understand and appreciate, this design of the conventional audiometer **2** has allowed a human test administrator to interrupt test tone testing to give instructions, error messages, and other voice commands. The conventional audiometer **2** has required intervention of a human test administrator, however, by selectively throwing relays **64***a,b*

and speaking into the microphone **62** of the talkover card **8***b*, in order to conduct hearing test with intermittent instructions and messages.

Multimedia Embodiments

Referring now to FIG. **4**, a multimedia audiometer **100**, according to embodiments of the present invention, may be described. The multimedia audiometer **100** includes a basic audiometer **200** having the basic elements of the conventional audiometer **2** (shown in FIG. **1**). That is, the multimedia audiometer **100** is also comprised of the microprocessor circuitry **4** and the audio circuitry **6** (or other similar processing and audio electronics and circuits) of the conventional audiometer **2** (shown in FIG. **1**). The earphone speakers **50** and the handswitch **52** are also interfaced with the basic audiometer **200**.

Although the multimedia audiometer **100** and the conventional audiometer **2** share these similar basic elements, the basic audiometer **200** is merely a subset of the entire multimedia audiometer **100**, as is apparent in FIG. **4**. In addition to the elements of the basic audiometer **200**, **2**, the multimedia audiometer **100** includes a computer **102**, such as a personal computer, another type of computer, or some other processing and storage device. The computer **102** may be equipped and connected with peripherals, such as a keyboard **106** and a display monitor **104**, as well other known input/output, communications, printing, and peripheral equipment. In any event, the computer **102** should have multimedia capabilities, that is, the computer **102** should be capable of producing sound waves and/or visual images from representative digital information stored, generated, and/or manipulated within or by the computer **102**.

The computer **102** may be conductively connected with the basic audiometer **200** through two interfaces: a communications interface **108** and a multimedia input interface **110**. The communications interface **108** may allow for serial, parallel, or other communications. If communications are serial, the communications interface **108** may connect the computer **102** with the RS232 port **8***a* (shown in FIG. **1**) in standard manner, as though the basic audiometer **200** is a peripheral to the computer **102**. The multimedia input interface **110** requires, however, that the conventional audiometer **2** be modified in certain respects to provide the basic audiometer **200** for multimedia automation of testing, as hereafter described.

Referring now to FIG. **5**, the communications interface **108** and the multimedia input interface **110** connect the computer **102** with the basic audiometer **200** to form the multimedia audiometer **100**, as shown in functional block form. A serial input/output port (not shown in detail) of the computer **102** may directly connect via the communications interface **108** with the RS232 port **8***a* of the basic audiometer **200**. A multimedia output port (not shown in detail) of the computer **102** may directly connect via the multimedia input interface **110** with a multimedia talkover card **118***b*, similar to the talkover cord **8***b* (shown in FIG. **3**) of the conventional audiometer **2**. The multimedia output port of the computer **102** may, for example, be a port of a sound card (not shown in detail) from which sound signals are output by the computer **102**. Alternatively or additionally, other multimedia outputs (not shown) of the computer **102**, for example, graphical image or video outputs, may connect with the multimedia input interface **110** in similar manner. The talkover card **8***b* (shown in FIG. **3**) of the conventional audiometer **2** configuration has not previously provided a port for connection of the multimedia input interface **110**. The conventional audiometer **2** may, therefore, be adapted to provide such port. The adapted conventional audiometer **2** is the basic audiometer **200**.

Referring now to FIG. **6**, a sound port **120** of a multimedia talkover card **118***b* for multimedia input to the basic audiometer **200** may be described. The sound port **120** connects with the multimedia input interface **110**, so that multimedia outputs of the computer **2** are input to the multimedia talkover card **118***b*. The sound port **120** may include a connector **120***a* to which the multimedia input interface **110** may be plugged. The connector **120***a* may be attached with two input leads **120***b*. The input leads **120***a,b* may be attached with an audio jack plug **121**. The audio jack plug **121** is insertable in an audio jack **122** connected to the amplifier **60** output. When the audio jack plug **121** is not inserted in the audio jack **122**, the output of the amplifier **60** is shorted prior to the switches **66***a*. When the audio jack plug **121** is inserted in the audio jack **122**, however, the circuit is completed and the computer **102** connected to the sound port **120** may supply multimedia input to the switches **66***a*. In effect, the microphone **62** is substituted with the multimedia input via the sound port **120**. All other features of the multimedia talkover card **118***b* are substantially the same as the features of the talkover card **8***b* of the prior technology.

Although the input leads **120***b* of the sound port **120** are shown as connected with an output of the amplifier **60** in the Figure, alternatively, the input leads **120***b* could in similar manner connect with inputs to the amplifier **60** or at some other location prior to or after the amplifier **60**. Furthermore, although the multimedia talkover card **118***b* is expressly described as a "card" to the basic audiometer **200**, it is to be understood that any other functional elements and circuitry that perform similarly, such as, for example, a relay circuit that switches between the tone generator of the basic audiometer **200** and the multimedia output from the computer **102**, as well as other possibilities, are all within the scope of the invention.

Now referring to FIG. **7**, in conjunction with FIGS. **4–6**, operations **300** of the multimedia audiometer **100** and the software driving those operations **300** are discussed. When power is supplied to the multimedia audiometer **100**, the basic audiometer **200**, as well as the computer **102**, may perform various set-up functions **302**. Those set-up functions **302** of the multimedia audiometer **100**, for example, boot-up and initialization of the computer **102** and start-up and initialization of the basic audiometer **200**, are conventional. The start-up and initialization of the basic audiometer **200** may be substantially the same as that of the conventional audiometer **2** (shown in FIG. **1**).

Generally, this start-up and initialization of the basic audiometer **200** may proceed, for example, as follows:

At turn-on, the basic audiometer **200** presents a first tone and a message appears on the display **18**. The basic audiometer **200** is now ready for operation. If a processing error by the CPU **12** is discovered during the turn-on, an appropriate message is displayed.

The following example illustrates an initialization procedure for the basic audiometer **200**. Keys of the keyboard **20** are indicated by [ ] and messages in quotes. To begin, press:

KEYBOARD	DISPLAY
[SPECIAL]	SPC00
[ENTER]	MM DD YY

Now enter today's date. For example:

KEYBOARD	DISPLAY	COMMENT
[04 30 96]	OM DD YY	

The message "mode pulsed" then appears on the display **18**. Press [NO] to switch to continuous mode. "Continuous Mode" will be displayed. Press [ENTER] when the desired code is displayed. The display should now read "1 KL AA AUTO " and then displays "PRESS [NEW TEST]". Other parameters which may be selected include the test other ear first and delete 8000 Hz. To do this, press:

KEYBOARD	DISPLAY	COMMENT
[SPECIAL]	SPC 04	
[04]	SPC 04	
[ENTER]	LEFT EAR FIRST	
[NO]	RIGHT EAR FIRST	
[ENTER]	1KR AA AUTO	(Now testing right ear first)
[SPECIAL]	SPC 06	
[06]	SPC 06	
[ENTER]	8KR SEL AUTO	
[NO]	8KR DEL AUTO	
[ENTER]	1KR AA AUTO	(8 Khz is deleted)

The basic audiometer **200** is now initialized.

Any or all of the above-mentioned parameters can be changed at any time by entering a desired special routine. Various "Special" codes that may be possible with the basic audiometer **200** of the multimedia audiometer **100** may, for example, include the following:

SPECIAL	FUNCTION
00	Initialization of audiometer
01	Enter date and time
02	Mode Pulsed/Continuous
03	Enter Examiner ID
04	Invent runtable to test better ear first
05	Select Printer Format
06	Select or Delete 8K
07	Select Baud rate
08	Turn on or off audio feedback for key pushes
09	Accelerated listening check
10	Check calibration date
11	Call Ram Rom check
12	Calibration mode and program calibration eeprom
13	Printer text
14	Not used
15	Display routine for time and date (no entry)
16	Not used
17	Display selected audiogram
18	Print selected audiogram or audiograms
19	Display and/or enter serial number
20	Not used

Software protocols to accomplish the start-up and initialization of the basic audiometer **200** may be stored in the memory **14**, **16** of the basic audiometer **200** or elsewhere. Processing and control for the start-up and initialization of the set-up functions **302** are performed by the CPU **12** of the basic audiometer **200**. Alternatively, the basic audiometer **200** could be controlled by the computer **102** to perform the start-up and initialization, or start-up and initialization could be controlled manually or in some other manner.

After the set-up functions **302**, including start-up and initialization of the basic audiometer **200**, are completed, the basic audiometer **200** may be ready to begin administering a new audiometric test of a test subject. A new test may be begun, for example, by pressing a key of the basic audiometer **200** or, alternatively, by a similar input to the computer **102**. Upon the start of the new test, the computer **102** may control the basic audiometer **200** by communication over the communications interface **108** (shown in FIGS. **4**–**5**).

If initial instructions to the test subject are desired, the computer **102** may control the basic audiometer **200** over the communications interface **108** (shown in FIGS. **4**–**5**). This control **304** may trigger the relay **64***a* and the relays **64***b* (shown in FIG. **2**) to close the switches **66***a* and open the switches **66***b* (shown in FIG. **2**), respectively. When the switches **66***a* are closed and the switches **66***b* opened in this manner, sound signals passed to the sound port **120** from the computer **102** over the multimedia input interface **110** are delivered through the amplifier **69** of the multimedia talk-over card **118***b* and through the earphone jack **48** to the earphone speakers **50**.

The particular sound signals so passed to the earphone speakers **50** may be derived from digital information stored or generated in, or read by, the computer **102**. The computer **102** may select and output **306** signals representative of the particular digital information. If the testing is just beginning, the signals so selected and output **306** may be initial instructions to the test subject about the test and the testing procedure. Of course, the particular signals could be representative of virtually any type of information which is subject to derivation from digital data. Although sound is described here as being derived from digital data, those skilled in the art will know and appreciate that digital data may be manipulated and processed in a multitude of ways to derive other types of information, for example, visual graphics and images and others.

After the computer has selected and output **306** the desired sound signals to the basic audiometer **200** and signals have been delivered to the test subject as sound waves through the earphone speakers **50**, the computer **102** again may control **308** the basic audiometer **200**. The control **308** at this instant may trigger the relay **64***a* to close the switches **66***a* and the relays **66***b* (shown in FIG. **2**) to open the switches **66***b*, respectively. The control **308**, then, causes the basic audiometer **200** to generate **310** a series of test tones, such as, for example, tones in accordance with the Hughson-Westlake procedure or another testing protocol.

When the switches **66***a* are closed and the switches **66***b* are opened because of the control **308**, the test tones generated **310** by the audio circuitry **6** of the basic audiometer **200** are delivered through the earphone jack **48** to the earphone speakers **50**. According to the particular testing protocol, the test subject may respond to the test tones by input **312** via the handswitch **52** connected to the basic audiometer **200**. The basic audiometer **200**, in cooperation with the computer **102**, will detect and determine any error **314** of the input **312** response.

If there is not any error **316**, then the basic audiometer **200** may continue to generate successive test tones **320** according to the particular test protocol, until the test is completed **322**. The successive test tones **320** are generated in the same

manner as previously described. That is, the basic audiometer **200** operates to generate test tones **310** delivered to the test subject; the test subject responds with input **312** via the handswitch **52**; and the audiometer **200**, in conjunction with the computer **102**, detects and determines **314** any error.

If an error **318** is detected and determined **314**, the computer **102**, based on its particular programmed logic, determines **324** whether to proceed **326** with the testing, to re-test **328**, or to perform some other function (not shown). Certain errors that may be encountered during the administration of the test include, for example, the following:

No response at 1 kHz, Error Code E1, signifies that the test subject is not responding to the test tone. The test subject may receive a multimedia sound message, generated by the computer **102** and passed through the earphone speakers **50**, as to how to take the test, for example, as follows:

"There has been no response for any tone in the initial test—as soon as you hear a tone cut it off by pressing and releasing the hand switch."

Then, the test may be restarted.

Failed to Establish Threshold, Error Code E2, signifies that the basic audiometer **200** is unable to establish a hearing threshold level (HTL) from the response of the test subject. The test subject may be instructed based on digital data of the computer **102**, for example, as follows:

"The audiometer has been unable to establish a threshold—listen for the tone and as soon as you hear the tone cut it off by pressing and releasing the hand switch."

The test may then recommence.

Hand Switch Error, Error Code E4, signifies that the test subject is not releasing the response handswitch **52**. The test subject may, for example, receive the following instructions generated from the digital data stored by computer **102**:

"The audiometer is recognizing the hand switch as being on for a length of time—as soon as you hear a tone cut it off by pressing and releasing the hand switch."

The test may then recommence.

Response no tone, Error Code E5, signifies that the test subject has responded at least three times when no tone or stimulus was present. A multimedia message, for example, as follows, may be delivered through the earphone speakers **50**:

"The audiometer is recognizing responses when no tone is present—as soon as you hear a tone cut it off by pressing and releasing the hand switch."

The test is, thereafter, restarted.

The foregoing error codes, multimedia messages, and operations are merely example possibilities. An example of an entire error code list is as follows:

Error Code	Indication	Multimedia Audiometer Response
AA	Not Tested	
DD	Deleted Frequency	
EE	No Response	Test Continues
EF	Test Incomplete	

-continued

Error Code	Indication	Multimedia Audiometer Response
EB	25 Presentations No HTL	Test Continues
E1	No Response 1 KHz	Stops Test Repeat Instructions
E2	1 KHz 25 Presentations No HTL	Stops Test Repeat Instructions
E3	1 KHz Retest Error	Stops Test Repeat Instructions
E4	Hand Switch Error	Stops Test Holding Switch MSG
E5	Response No Tone	Stops Test Response w/window closed
E6	Error For Second Time	Stops Test Examiner Intervention
E7	Max. Failed Frequencies >6	Stops Test Examiner Intervention
E8	Hardware Error	Only seen at Turnon and After EPROM Diagnostic Check

Error Codes That Do Not Stop Test
EE
Error Codes that Get Instructions and Resume Testing
EB- Same as E2 message
E1
E2
E4
E5
Error Codes That Stop Test and Pop Up Message on PC for Operator Test Does Not Restart
E3
E6
E7

In the case that a re-test **328** is warranted because of an error or otherwise, the operations **300** begin anew with the computer control **304** of the basic audiometer **200** over the communications interface **108** (shown in FIGS. **4–5**) to trigger the relays **64***a,b*. The testing thereafter proceeds through the steps of selection and output **306**, computer control **308**, test tone generation **310**, test subject response input **312**, and detection and error determination **314**.

Once the entire test protocol is completed in the foregoing manner, the test is completed **322**. The computer **102** may then control **330** the basic audiometer **200** to trigger the relays **64***a,b* to close the switches **66***a* and to open the switches **66***b*. The control **330** is accomplished in the manners previously described by communications between the computer **102** and the basic audiometer **200** over the communications interface **108**.

After the control **330** so sets the switches **66***a,b*, the computer **102** may further select and output **340** sound signals, which sound signals are derived from digital data stored, generated or read by the computer **102**. The sound signals may travel to the earphone jack **48** and the earphone speakers **50** to deliver final instructions and messages to the test subject.

Numerous alternatives and variations are possible for the multimedia audiometer **100**. For example, digital data stored, generated or read by the computer **102** may be representative of a wide variety of sounds, images, video, or other multimedia features. In certain embodiments, the particular digital data may allow the test subject to select any of a number of different languages through which testing is administered. Further, digital data may be manipulated by

the computer **102** in such a manner that multiple simultaneous tests may be administered. There are, of course, numerous other possibilities.

There are also many possible variations and alternatives in the configuration of the computer **102** and the basic audiometer **200** by providing the audiometer with additional memory, processing, wave sound generation, and appropriate software. Alternatively, the computer **102** could include test tone generation means and appropriate software programming to perform the functions of the basic audiometer **200**. Even further, the multimedia audiometer **100** could be implemented by using a programmable digital tape player or compact disc (CD) player and allowing the basic audiometer **200** to select desired tracks to play. Other alternatives may be possible, it being understood that those skilled in the art will generally know and appreciate that the employment of computer or other control of instrumentation operations during test administration and the use of multimedia features for instruction, messages, and other herebefore required human administrative actions is possible with the incorporation of digital data, according to the embodiments of the present invention, from which are derived multimedia features.

It is to be understood that multiple variations, changes and modifications are possible in the aforementioned embodiments of the invention. Although illustrative embodiments of the invention have been shown and described, a wide range of modification, change, and substitution is contemplated in the foregoing disclosure and, in some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the foregoing description be construed broadly and understood as being given by way of illustration and example only, the spirit and scope of the invention being limited only by the appended claims.

What is claimed is:

1. A method for automatedly administering an audiometric test, comprising the steps of:

controlling an audiometer to selectively switch the audiometer output between test tones generated by the audiometer and sound signals generated from digital information;

first switching the audiometer output to sound signals when the step of controlling indicates a particular condition;

outputting sound representative of the sound signals after the step of first switching;

second switching the audiometer output to test tones after the step of outputting; and

outputting test tones until the next step of first switching.

2. The method of claim **1**, wherein the particular condition is selected from the group consisting of a beginning of a new test, a completion of a current test, and a test error.

3. A multimedia audiometer, comprising:

means for outputting sound signals generated from digital information;

means for outputting test tones;

means for switching between the means for outputting sound signals and the means for outputting test tones, the means for switching being communicatingly connected with the means for outputting sound signals and the means for outputting test tone; and

means for controlling the means for switching, the means for controlling being communicatingly connected with the means for switching.

4. A multimedia audiometer, comprising:

a multimedia computer;

a tone generator;

a switch connected with the computer and the tone generator;

wherein the switch selectively causes either the tone generator or the computer to output sound waves and the computer controls the switch.

5. An instrument, the instrument conducts a test protocol on a test subject, the test protocol comprises an output by the instrument followed by an input to the instrument, the test subject determines the input, the input may be positive, negative, or null, comprising:

an output generator;

an input detector for detecting the input;

a digital data storage for storing a digital data;

a multimedia converter, the multimedia converter converts the digital data to an analog signal; and

logic circuitry connected to the input detector, the digital data storage, the multimedia converter, and the output generator, for logically operating on the input, reading the digital data, delivering the digital data to the multimedia converter, and controlling the output generator.

6. The instrument of claim **5**, wherein the output generator comprises:

an analog test tone generator; and

a sound wave generator for producing sound waves representative of the analog signal.

7. The instrument of claim **6**, wherein the output generator further comprises a switch for switching the output generator between the analog test tone generator and the sound wave generator.

8. A diagnostic instrument, comprising:

means for outputting an audible sound;

means for generating a test tone;

means for storing a digital data;

means for generating an analog signal derived from the digital data;

means for switching an output of the means for outputting between the test tone and the analog signal, the means for switching being electrically connected to the means for generating a test tone and the means for generating an analog signal;

means for processing;

means for inputting, the means for inputting connects the means for processing to the means for outputting; and

means for communicating, the means for communicating connects the means for processing to the means for outputting, the means for generating the test tone, the means for storing the digital data, the means for generating the analog signal, the means for switching, and the means for inputting.

9. A method of performing a diagnostic test protocol, comprising the steps of:

outputting an audible sound;

generating a test tone;

storing a digital data;

generating an analog sound derived from the digital data;

switching the audible sound from the step of outputting between the test tone and the analog signal;

processing the digital data; and

controlling the steps of outputting, generating the test tone, storing, generating the analog sound, and switching.

10. A multimedia audiometer, comprising:

a basic audiometer;

a computer wherein the computer comprises a sound wave generator for converting a digital information to analog signals with respect of the digital information;

a multimedia input interface communicatingly connecting the computer and the basic audiometer; and

a communications interface communicatingly connecting the computer and the basic audiometer.

11. A multimedia audiometer, comprising:

a basic audiometer;

an output speaker connected to the basic audiometer;

a computer;

a multimedia input interface communicatingly connecting the computer and the basic audiometer;

a communications interface communicatingly connecting the computer and the basic audiometer; and

a switch connected to the multimedia input interface and the basic audiometer, in a first position, and the output speaker, in a second position, for switching between a first signal communicated over the multimedia input interface and a second signal generated by the basic audiometer as an output for the output speaker.

12. A multimedia audiometer, comprising:

a basic audiometer;

a computer wherein the computer and the basic audiometer communicate over the communications interface and the computer controls the operation of the audiometer over the communications interface;

a multimedia input interface communicatingly connecting the computer and the basic audiometer; and

a communications interface communicatingly connecting the computer and the basic audiometer.

13. The multimedia audiometer of claim 11, wherein the computer and the basic audiometer communicate over the communications interface and the computer controls the operation of the audiometer over the communications interface and wherein the switch comprises a relay and the computer controls the relay in order to switch between the first signal communicated over the multimedia input interface and the second signal generated by the basic audiometer as the output for the output speaker.

14. The multimedia audiometer of claim 13, wherein the computer comprises a sound wave generator for converting a digital information stored by the computer to analog signals in respect of the digital information.

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(12) EX PARTE REEXAMINATION CERTIFICATE (7074th)

United States Patent

Braun et al.

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(45) Certificate Issued: *Sep. 22, 2009

(54) **MULTIMEDIA FEATURE FOR DIAGNOSTIC INSTRUMENTATION**

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(51) **Int. Cl.**
A61B 5/00 (2006.01)

(52) **U.S. Cl.** **600/559**

(58) **Field of Classification Search** ..... None
See application file for complete search history.

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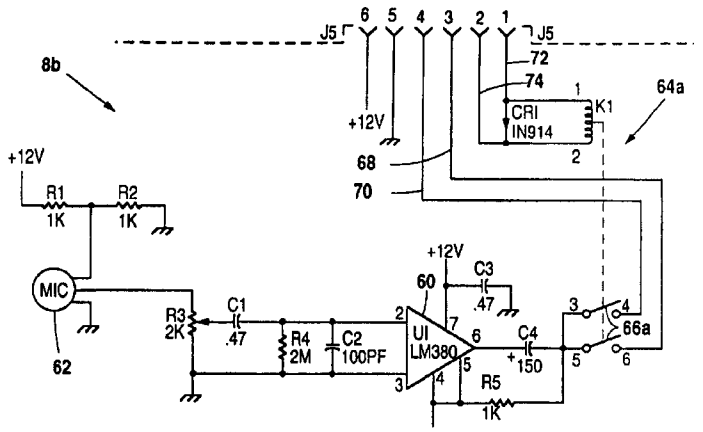
Primary Examiner—Mary Steelman

(57) **ABSTRACT**

A method for automatedly administering an audiometric test includes the steps of controlling an audiometer to selectively switch the audiometer output between test tones generated by the audiometer and sound signals generated from digital information; first switching the audiometer output to sound signals when the step of controlling indicates a beginning of a new test, a completion of a current test, or a test error; outputting sound representative of the sound signals after the step of first switching; second switching the audiometer output to test tones after the step of outputting; and outputting test tones until the next step of first switching.



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EX PARTE REEXAMINATION CERTIFICATE ISSUED UNDER 35 U.S.C. 307

THE PATENT IS HEREBY AMENDED AS INDICATED BELOW.

AS A RESULT OF REEXAMINATION, IT HAS BEEN DETERMINED THAT:

Claims **1–14** are cancelled.

ONLY THOSE PARAGRAPHS OF THE SPECIFICATION AFFECTED BY AMENDMENT ARE PRINTED HEREIN.

Column **10**, lines **43–53**:

After the computer has selected and output 306 the desired sound signals to the basic audiometer 200 and signals have been delivered to the test subject as sound waves through the earphone speakers 50, the computer 102, again

may control 308 the basic audiometer 200. The control 308 at this instant may trigger the relay 64a to **[**close**]** *open* the switches 66a and the relays 66b (shown in FIG. **2**) to **[**open**]** *close* the switches 66b, respectively. The control 308, then, causes the basic audiometer 200 to generate 310 a series of test tones, such as, for example, tones in accordance with the Hughson-Westlake procedure or another testing protocol.

Column **10**, lines **54–63**:

When the switches 66a are **[**closed**]** *opened* and the switches 66b are **[**opened**]** *closed* because of the control 308, the test tones generated 310 by the audio circuitry 6 of the basic audiometer 200 are delivered through the earphone jack 48 to the earphone speakers 50. According to the particular testing protocol, the test subject may respond to the test tones by input 312 via the handswitch 52 connected to the basic 5 audiometer 200. The basic audiometer 200, in cooperation with the computer 102, will detect and determine any error 314 of the input 312 response.

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